replaced by "resonant frequency of the smart panel" because the object of the present invention is to prevent a noise propagation through the smart panel, not just through the board structure.

This change is supported by the description in paragraph [0003] "Namely, the insertion loss of the panel may be increased in an intermediate/high frequency band by coupling an absorption member with a board member. In this case, it is impossible to prevent a decrease of an insertion loss *in a resonance frequency of a panel.*" and, in paragraph [0016], "...When the noise *having a resonance frequency component of the smart panel* transfers the pressure to the piezoelectric member 3, the vibration energy and sound energy are converted into an electrical energy by the piezoelectric member".

Amended claim 1 now includes the features of claim 2, now cancelled.

The Sec. 103 Rejection of Claim 1

(1) The examiner argued that since Baz discloses a piezo patch and visco-elastic material to which a beam is attached and Burdisso discloses tuning a damping system to a resonance frequency, the present invention can be derived from the combination of Baz and Burdisso. However, the present invention employs a passive damping in which the piezo unit does not require a control signal in order to decrease noise. Baz and Burdisso each relate to active damping where a piezo patch requires a control signal. The piezoelectric unit in the present invention is an energy dissipating means, whereas a piezo patch functions as an actuator in Baz and Burdisso. Hence, the present invention having a passive energy dissipating means is completely different from Baz and Burdisso which each require active control. The present amendment of independent claims 1 and 5 more clearly indicates that the sound absorption member decreases noise of an intermediate and high frequency portion of the audible frequency band, basis for which is found in the specification at paragraphs [0003] and [0005] The

piezoelectric unit is now more specifically defined in claims 1 and 5 by introducing the features previously found in claim 2, now cancelled.

Generation of an active control signal require a circuit having a very complex constitution. The present invention does not require a complex damping control signal generating circuit. Therefore, the present invention has a starting point completely different from those of Baz and Burdisso.

(2) In particular, the preferred embodiment of the smart panel of the present invention is a hybrid-type smart panel in which an absorption member reduces noise of an intermediate/high frequency band and a piezoelectric unit with shunt circuit reduces noise of a low frequency band corresponding to a resonance frequency band of the smart panel. Low frequency noise, in which it is relatively simple to detect a resonance modes and tune a circuit therefrom is mostly decreased by a piezoelectric unit with shunt circuit, and noise of an intermediate/high frequency band where it is very difficult to detect resonance modes and tune the corresponding circuits due to numerous resonance modes is mostly decreased by a sound absorption member.

The above is supported by the description, paragraph [0002]. "As the use of a sound absorption is increased, an insertion loss is increased in an intermediate frequency and a high frequency band" Further, see the paragraph [0006] description of a smart panel "which is capable of increasing an insertion loss in a resonance frequency of a smart panel and maximizing a soundproof effect by increasing an insertion loss in an intermediate/high frequency band". Consequently, the present invention produces a noise reduction effect in a wide band including a low frequency band and an intermediate/high frequency band.

Baz is an active damping requiring an active signal and thus is only effective on a low frequency having a simple vibration mode. Since an intermediate/high frequency band has numerous vibration modes and it is actually impossible to generate an active signal corresponding

to numerous vibration modes, it is obvious that the Baz invention is vulnerable to controlling vibration of an intermediate/high frequency band.

Further, since Burdisso discloses a system of active damping requiring a control signal, it, like Baz, has little effect on damping vibration of an intermediate/high frequency band.

Hence, the present invention which effectively reduces noise in a wide band from a low frequency band to an intermediate/high frequency band is superior to Baz and Burdisso which are less effective in reducing noise in an intermediate/high frequency band.

(3) The examiner argues that Baz already includes a passive physical damping. However, the visco-elastic material of Baz has a different performance from that of the absorption member of the present invention. The visco-elastic material of Baz merely absorbs a bending energy from a external force and does not have a unique performance in a wide band of vibration frequencies. Further, in the event of a simultaneous performance of the visco-elastic material and the constrained layer, there is no unique effect corresponding to a particular vibration frequency band, which is particularly described in Baz at Col. 7, beginning at line 13, "The increase of the shear deformation of the visco-elastic layer, during the entire vibration cycle, is accompanied with an increase in the energy dissipated. Furthermore, the shrinkage (or expansion) of the active constraining piezo-electric layer during the upward motion (or during the downward motion) produces a bending moment on the beam which tends to bring the beam back to its equilibrium position. Therefore, the dual effect of the enhanced energy dissipation and the additional restoring bending moment will quickly damp out the vibration of the flexible beam."

The absorption member of the present invention for a noise reduction effect mostly in an intermediate/high frequency band by performing in an intermediate/high frequency band is different from the visco-elastic material of Baz. In other words, the visco-elastic material and the constrained layer of the Baz invention do not have their own performing frequency band but

perform together in any frequency band. This, differs from the present invention in which each element has its own shared frequency band for performance. Therefore, noise reduction in intermediate/high frequency band and resonance low frequency band of the smart panel is mostly performed by different elements. This concept is not disclosed or suggested in Baz and Burdisso.

(4) The examiner argued that the Wu invention discloses employing a passive component so as to reduce the structural vibration. The examiner also argued that the Wu invention includes a shunt circuit connected to a piezoelectric material for reducing vibration. Hence, the examiner argued that the present invention wherein a shunt circuit is connected to a piezoelectric unit is derived according to the instruction of the Wu invention on the basis of Baz and Burdisso. However, Wu relates to a method of tuning a shunt circuit in which vibration having a multiple vibration mode is decreased by a single shunt circuit. Hence, the Wu invention is not directed to a specific application with a shunt circuit but a method of tuning a shunt circuit for damping a multiple vibration mode.

Baz and Burdisso are systems involving active damping different from the smart panel of the present invention. Hence, even an application of the teachings of Wu to Baz and Burdisso does not result in the smart panel of the present invention wherein an absorption member is responsible for a noise reduction of an intermediate/high frequency band and a piezoelectric unit with shunt circuit is responsible for a noise reduction of a relatively low resonance frequency band of the smart panel.

<u>The Sec. 103 Rejection of claim 5</u>

Independent claim 5, as amended, now includes features previously found in claim 2 and therefore is believed non-obvious for the same reasons as discussed above in conjunction with the rejection of claim 1.

<u>The rejection of claim 6</u>

The examiner argued that the constitution of the present invention that an air layer formed between the board structures is derived from Fig. 32 of Baz. However, Fig. 32 of Baz illustrates active constrained layer damping of torsional mode of cylindrical shells, which is completely different from the constitution of the present invention that an air layer is formed between the layered board structures. Also, claim 6 is believed non-obvious for the same reasons as claim 5 is considered non-obvious.

Favorable reconsideration of the claims, as amended, and early allowance is respectfully requested.

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SMART PANEL FOR DECREASING NOISE IN WIDE BAND FREQUENCY

BACKGROUND OF THE INVENTION

Field of the Invention

[1] The present invention relates to a soundproof panel, and in particular to a smart panel capable of decreasing a noise in a wide band frequency.

Description of the Background Art

[2] Generally, a panel is formed of a board member(or a board structure) or a combined member of a board member and a sound absorption member or two kinds of board members and a sound absorption member. The above-described panel has an insertion loss decreased in a resonance frequency of ~~a board member~~ the panel. As the use of a sound absorption is increased, an insertion loss is increased in an intermediate frequency and a high frequency band. An insertion loss of a panel having a double board member is increased compared to a panel of a single board member. The insertion loss may be decreased in a resonance frequency of a space formed by a board member and two board members.

[3] Namely, the insertion loss of the panel may be increased in an intermediate/high frequency band by coupling an absorption member with a board member. In this case, it is impossible to prevent a decrease of an insertion loss in a resonance frequency of a panel.

[4] In order to prevent the decrease of an insertion loss in a resonance

frequency, there is a method in which a viscoelasticity member is attached to a board member. However, since the elastic member has a characteristic in which the viscoelasticity characteristic is decreased in a wide frequency region. Therefore, it is impossible to obtain a certain characteristic which is proper to a certain frequency. In addition, the weight of the board member is increased due to a viscoelasticity member attached for increasing the decreasing effect of the viscoelasticity characteristic. The increase of the mass may cause an additional driving force for a transfer mechanism for thereby decreasing the performance of the system.

SUMMARY OF THE INVENTION

[5] Accordingly, it is an object of the present invention to provide a smart panel for decreasing a noise in a wide band frequency which is capable of maximizing a soundproof effect by preventing a decrease of an insertion loss in a resonance frequency of ~~a board structure~~ the smart panel.

[6] It is another object of the present invention to provide a smart panel for decreasing a noise in a wide band frequency which is capable of increasing an insertion loss in a resonance frequency of a ~~board structure~~ smart panel and maximizing a soundproof effect by increasing an insertion loss in an intermediate/high frequency band.

[7] In the present invention, a piezoelectric member connected with a

shunt circuit is attached to the board structure, and a piezoelectric damping effect is obtained for changing an electric energy which occurs in the piezoelectric member into a thermal energy based on a tuning operation of the shunt circuit for thereby maximizing the insertion loss at the resonance frequency of the ~~board structure~~ smart panel.

[8] To achieve the above objects, there is provided a smart panel for decreasing a noise in a wide band frequency which includes a board structure for decreasing a noise of an audible frequency band, a sound absorption member attached to one surface of the board structure for decreasing a noise of an audible frequency band, and a piezoelectric unit attached to the board structure for decreasing the noise when the same audible frequency as the resonance frequency of the ~~board structure~~ smart panel is propagated.

BRIEF DESCRIPTION OF THE DRAWINGS

[9] The present invention will become better understood with reference to the accompanying drawings which are given only by way of illustration and thus are not limitative of the present invention, wherein:

[10] Figure 1 is a view illustrating a smart panel according to an embodiment of the present invention;

[11] Figure 2 is an equivalent circuit diagram illustrating an electrical

characteristic of a piezoelectric member according to the present invention;

[12] Figure 3 is a view illustrating a shunt circuit of Figure 1; and

[13] Figure 4 is a view illustrating a smart panel according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[14] Figure 1 is a view illustrating a smart panel according to an embodiment of the present invention, Figure 2 is an equivalent circuit diagram illustrating an electrical characteristic of a piezoelectric member according to the present invention, and Figure 3 is a view illustrating a shunt circuit of Figure 1.

[15] A smart panel according to an embodiment of the present invention includes a board structure 1, a sound absorption member 2, a piezoelectric member 3, and a shunt circuit 4. The board structure 1 supports the sound absorption member and decreases a noise in an audible frequency band. The sound absorption member 2 is attached to one side of the board structure 1 for decreasing a noise of an audible frequency band. A piezoelectric unit includes a plurality of piezoelectric members 3 attached to another side of the board structure 1, and a shunt circuit 4 electrically connected with each piezoelectric member 3 for increasing an insertion loss (namely, a soundproofing effect) in the resonance frequency of the ~~board structure 1~~. smart panel. The piezoelectric member 3

and the shunt circuit 4 are connected for obtaining a maximum soundproof effect by measuring an electrical impedance value of the piezoelectric member 3 attached to the board structure 1 and adjusting the impedance value through the shunt circuit 4 for thereby implementing an electrical resonance

[16] The operation of the smart panel according to the present invention will be explained. When a sound and vibration energy which transfers energy in a noise form reaches at the smart panel, a part of the energy is absorbed by the board structure 1, and almost part of the noise having a certain audible frequency band is absorbed by the sound absorption member 2. However, the noise having a resonance frequency of the ~~board structure 1~~ smart panel is not absorbed by the ~~smarty~~ smart panel but transmits. In order overcome the above problems, the piezoelectric member 3 is attached to the board structure 1. At this time, the piezoelectric member 3 is preferably attached to an anti-nodal point which generates a maximum displacement of the board structure 1. Here, the points which generate the maximum displacement correspond to the points which maximize the insertion loss. Generally, it represents that the vibration of the board member is highest. However, when the frequency is varied, the position is changed. Therefore, an optimization method is used. When the excitation frequency range is determined, the vibration mode which generates the sound in maximum is checked in the above range for thereby determining the anti-nodal point of the mode in which the sound generation is

maximized. If there are a plurality of modes in the excitation frequency range, it is difficult to determine. Therefore, the points are optimized. The piezoelectric member 3 is attached to the board structure 1. When the noise having a resonance frequency component of the smart panel transfers the pressure to the piezoelectric member 3, the vibration energy and sound energy are converted into an electrical energy by the piezoelectric member 3. As shown in Figure 2, the piezoelectric member 3 may be formed of a resistor, an inductor, and a capacitor.

[17] If a resonance does not occur in the piezoelectric member 3, it is impossible to receive the vibration and noise in a maximum energy which is received by the piezoelectric member 3. In order to overcome the above problem, the shunt circuit 4 is connected with the piezoelectric member 3. The shunt circuit 4 is tuned so that an electrical resonance occurs together with the electric component of the piezoelectric member 3, so that the piezoelectric member 3 absorbs the maximum energy amount. Namely, the characteristic of the shunt circuit 4 obtains a noise reduction effect in the ~~board structure~~ smart panel having different resonance frequency.

[18] The tuning method for obtaining an electric resonance by the piezoelectric unit will be explained. The piezoelectric member 3 is attached to the board structure 1, and then an electric impedance is measured at the piezoelectric member 3. The sizes of the resistor R and the inductor L of the shunt circuit 4 are adjusted so that the

~~board structure 1~~ smart panel has an electric resonance based on the measured impedance. A plurality of the piezoelectric members 3 are attached at the maximum displacement point of the board structure film 1, and then an electric impedance is measured using the impedance measuring unit. The measured impedance of the piezoelectric member 3 is formed in a ~~van dyke~~ Van Dyke model which is an equivalent circuit mode of the piezoelectric member 3 based on the electric impedance of the piezoelectric member 3 attached to the board structure 1. Each coefficient of the Van dyke model is obtained using an exclusive program. As shown in Figure 3, the shunt circuit 4 is a circuit in which the resistor R and the inductor L are connected in series or in parallel. The shunt circuit 4 is connected with the Van Dyke model which represents each resonance mode of the smart panel ~~board structure 1~~. The values of the resistor R and the inductor L of the shunt circuit 4 are designed for thereby obtaining the maximum electric energy value. Namely, it is designed so that the electric resonance is obtained. The above tuning process is performed with respect to each resonance mode, so that it is possible to implement an electric resonance with respect to the multiple mode.

[19] Figure 4 is a view illustrating the smart panel according to another embodiment of the present invention. The smart panel according to another embodiment of the present invention includes a plurality of board structures 1 which are distanced from each other by a certain distance, a sound absorption member 2 attached one board structure

1 among the ~~opposite~~ board structures 1 for forming an air layer 5 between the remaining board structures 1, and a piezoelectric member 3 and a shunt circuit 4 of the piezoelectric unit. The board structures 1 decrease the noise of the audible frequency band, and the sound absorption member 3 is attached to an inner surface of one board structure 1 among the board structures 1 for thereby decreasing the noise of the audible frequency band. The piezoelectric member 3 which is a component of the piezoelectric unit is attached to the opposite surface of the board structure 1. Each shunt circuit 4 is electrically connected with the piezoelectric member 3 attached to the board structure 1.

[20] The electric impedance value of the piezoelectric member 3 attached to the board structure 1 of Figure 1 is measured with respect to the smart panel as shown in Figure 4, and then the impedance value is adjusted through the shunt circuit 4 for thereby obtaining an electric resonance, whereby it is possible to obtain the maximum soundproof effect.

[21] In the above embodiments of the present invention, the air layer 5 is formed between the sound absorption member 2 and the board structure 1 as shown in Figure 4. In a preferred embodiment of the present invention, the smart panel may be implemented by inserting the sound absorption member 2 between the board structures 1without forming the air layer 5.

[22] ~~Ad~~ As described above, in the present invention, it is possible to maximize the soundproof effect by preventing the insertion loss decrease in the ~~board structure~~ smart panel resonance frequency by electrically resonating the piezoelectric member attached to the board structure through the shunt circuit. In addition, the performance of the smart panel may be maximized by easily implementing the piezoelectric reduction with respect to the multiple modes of the smart panel ~~board structure~~.

[23] As the present invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its spirit and scope as defined in the appended claims, and therefore all changes and modifications that fall within the meets and bounds of the claims, or equivalences of such meets and bounds are therefore intended to be embraced by the appended claims.

CLAIMS

1. (Currently amended) In a smart panel for a wide band noise reduction, an improved smart panel for a wide band ~~nose~~ noise reduction, comprising:

a board structure for decreasing a noise of an audible frequency band;

a sound absorption member attached to one surface of the board structure for decreasing a noise of an intermediate and high frequency portion of the audible frequency band; and

a piezoelectric unit attached to the board structure for decreasing the noise when the same audible frequency as the resonance frequency of the ~~board structure~~ smart panel is propagated, wherein said piezoelectric unit includes a plurality of piezoelectric members attached to the back surface of the board structure to which the sound absorption member is attached, and a shunt circuit connected with the piezoelectric members.

2. (Cancelled)

3. (Currently amended) The panel of claim ~~[[2]]~~ 1, wherein said piezoelectric members are attached to an anti-nodal point which generates a maximum displacement of the board structure for maximizing the noise reduction effect.

4. (Currently amended) The panel of claim ~~[[2]]~~ 1, wherein said shunt circuit is formed of a resistor and an inductor device and is tuned for electrically resonating an

electric impedance of each piezoelectric member.

5. (Currently amended) In a smart panel for a wide band noise reduction, an improved smart panel for a wide band noise reduction, comprising:

~~a board structure~~ board structures for decreasing a noise of an audible frequency band;

a sound absorption member attached to an inner surface of one of the board ~~structure among the opposite board~~ structures for decreasing the noise of an intermediate and high frequency portion of the audible frequency band; and

a piezoelectric unit attached to the board ~~structure~~ structures or decreasing the noise when the same audible frequency as the resonance frequency of the ~~board structure~~ smart panel is propagated, wherein said piezoelectric unit includes a plurality of piezoelectric members attached to the board structures and a shunt circuit connected with the piezoelectric members.

6. (Currently amended) The panel of claim 5, wherein ~~in said sound absorption member,~~ an air layer is formed between the other of the board ~~structure positioned in the opposite surfaces~~ structures and the sound absorption member.

ABSTRACT OF THE DISCLOSURE

The present invention relates to a soundproof panel, and in particular to a smart panel for decreasing a noise in a wide band. The smart panel according to the present invention includes a board structure for decreasing a noise of an audible frequency band, a sound absorption member attached to one surface of the board structure for decreasing the noise of an audible frequency band, and a piezoelectric ~~noise~~ unit attached to the board structure for decreasing the noise when the same audible frequency as the resonance frequency of the ~~board structure~~ smart panel is propagated for thereby maximizing the insertion loss in the resonance frequency of the ~~board structure~~ smart panel.